Kinetic Metallization™

Repair of IVD Al Coatings and Mg Alloys
Aircraft Components Using
Portable Kinetic Metallization Systems

NAVAIR SBIR Ph I & II Contract #N68335-05-C-0296
NAVAIR SBIR Ph I Contact #N68335-07-C-0448

SERDP/ESTCP Session-6 "Cd Replacements"

Inovati

Ralph Tapphorn, VP of Technology

Feb. 27, 2008

Report Documentation Page

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Problem - Field & Depot Repair of Damaged IVD-Al & Mg Alloys

- **Aircraft Components**
  - Landing Gear & HS Steel
  - Mg Alloy Gearboxes
  - IVD-Al field repair
- **Customer Requirements**
  - On aircraft carriers & depots
  - Environmentally sustainable
  - Meets Navy JTP-2003
  - **Portable system & Handheld spray gun**
  - Robotic deployment for OEM Applications

Organizations & Platforms with Needs for Coating Repairs

- NADEP Facilities
  - PEO(T) F/A-18, EA-18G
  - PMA-271 E-6B
  - PMA-276 H-1
  - PMA-275 V-22
  - JSF JPO F-35 Lightning II
- Air Force Depot Facilities
  - F-22
  - C-17
- Commercial Aircraft
  - A380 & B787

Introduction to Kinetic Metallization™ (KM)

- Metal deposition through particle impact
- low-temperature << melting point
- high particle velocity > 500 m/s
- gas velocity below Mach 1
  - He, 300K, 980 m/s
  - GN2, 300K, 330 m/s

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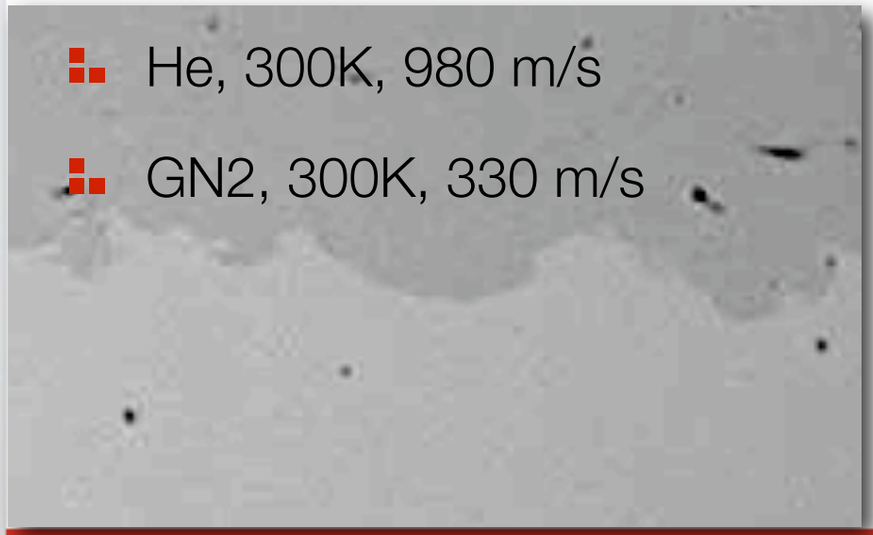
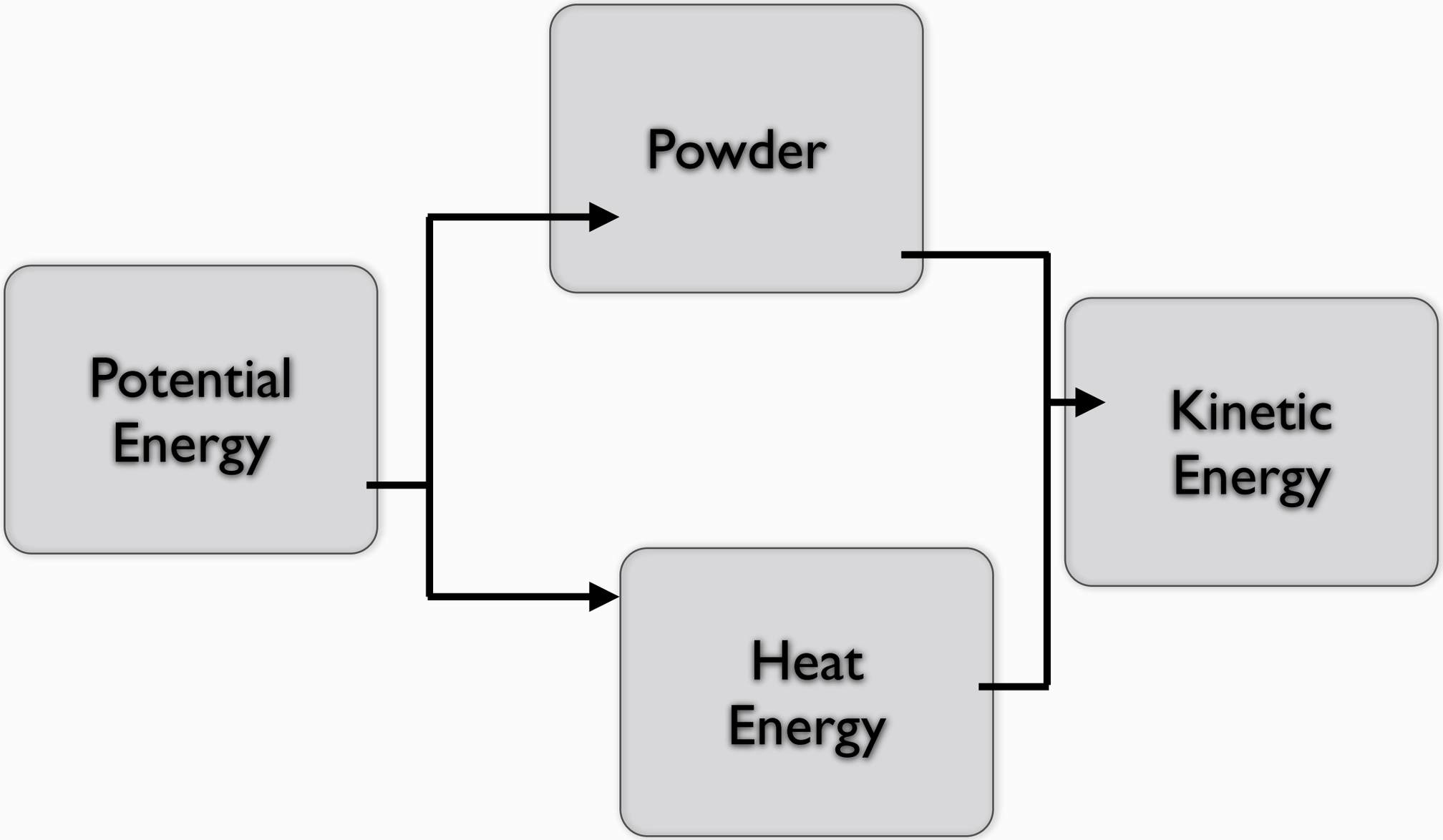


Powder

Potential Energy

Kinetic Energy

Heat Energy


Powder
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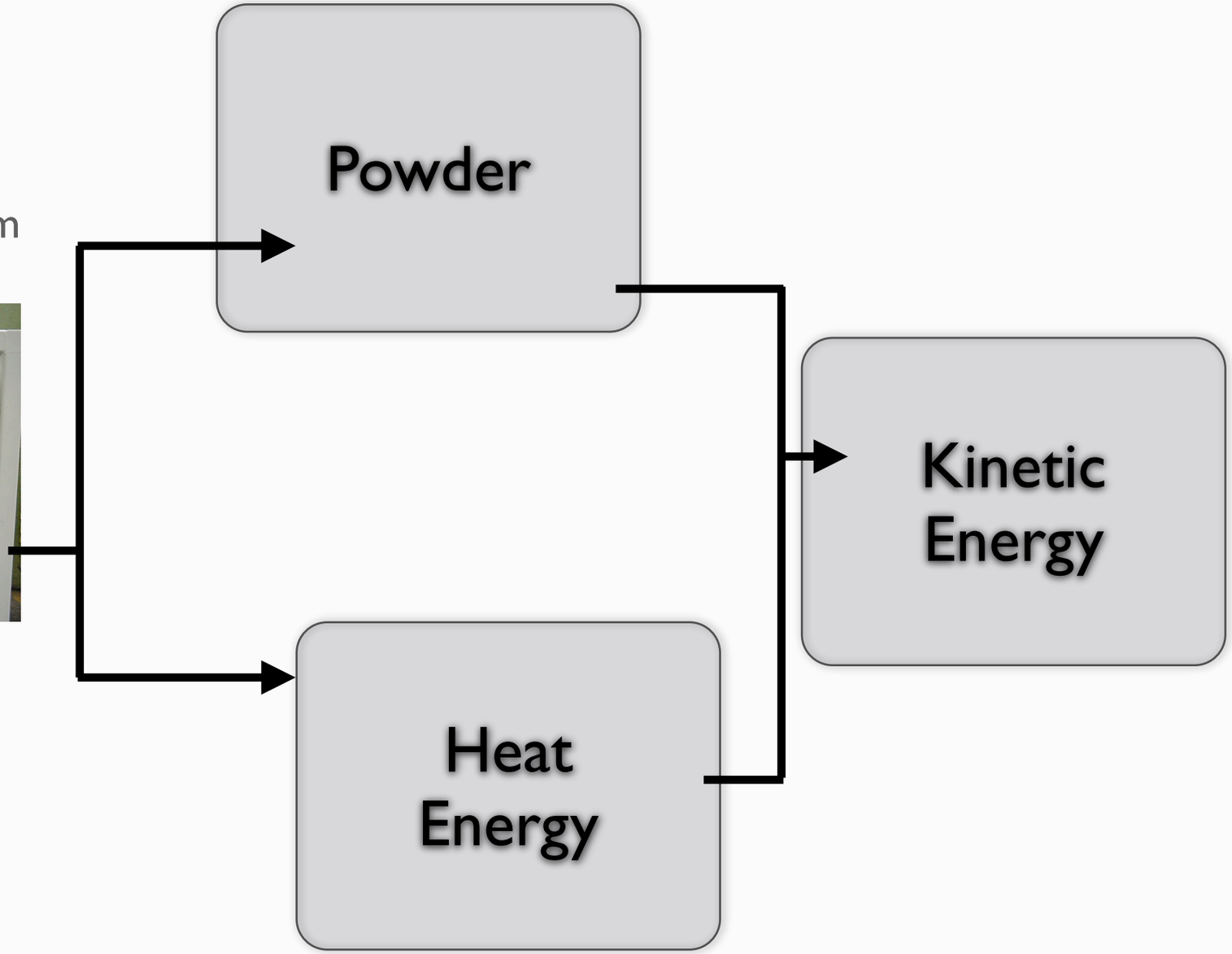
Helium Storage System



Helium Storage System

Powder Fluidizing Unit

Heat Energy

Kinetic Energy

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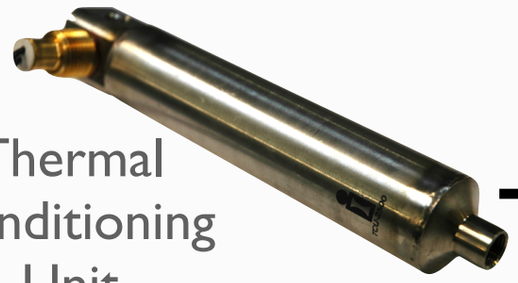
Helium Storage System

Powder Fluidizing Unit

Thermal Conditioning Unit



Kinetic Energy

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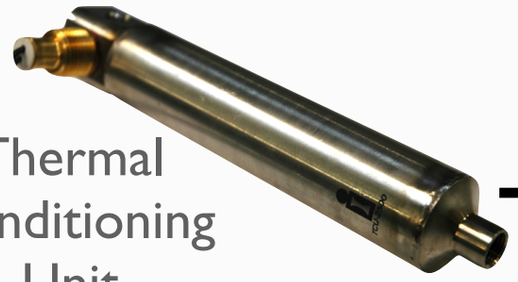


Deposition Nozzle

Kinetic Metallization Systems

- Low temperature & Pressure (1 MPa)
- KM-CDS, KM-PRO, & Portable KM
- Customers Worldwide (US, Japan, Australia, China)
- 4 units delivered to Japan last year

KM Coatings

- Al-Trans® corrosion resistant
- WC-Co & Cr_3C_2-NiCr wear/corrosion resistant
- MCrAlY wear/oxidation resistant

KM Handheld Gun

KM-CDS 2.x

KM-3.x

KM Portable System

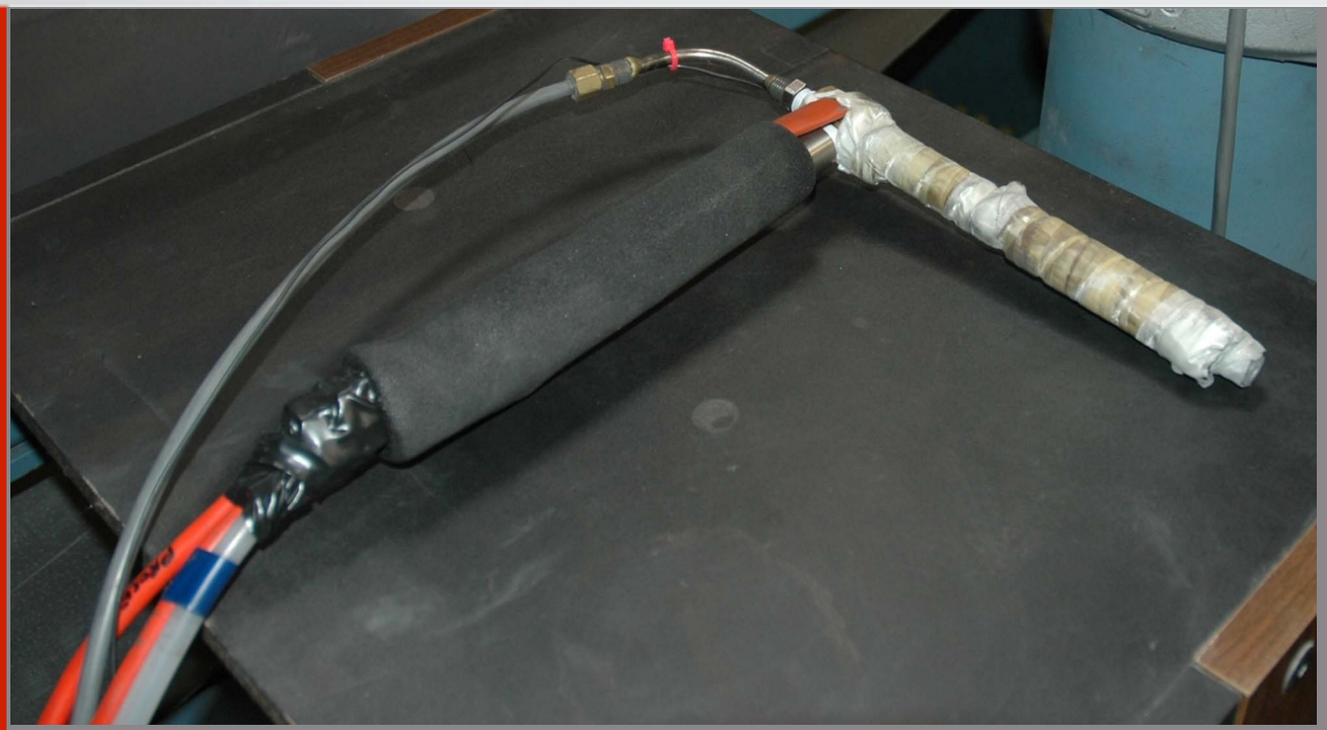
KM Compared to CS & HVOF

	KM	CS	HVOF
Max. Temp.	400℃	800℃	1650℃
Heat Source	2.5kW Integral	47kW Remote	Combustion
Accelerant Gas	He, N_2, He/N_2	He, N_2, He/N_2	Explosive Comb.
Bonding Mechanism	Metallurgical	Metallurgical	Mechanical
Powder Size	0.5 to 45µm	< 100 µm	+15µm, -44µm
Powder Dispenser	Brush-Sieve	TS Feeder	TS Feeder
State of Deposition	Solid	Solid	Liq./Semi-solid
Gun Pressure	<1MPa	>4MPa	<1 MPa
Gun/Nozzle Mass	1 kg	20 kg est.	> 4 kg

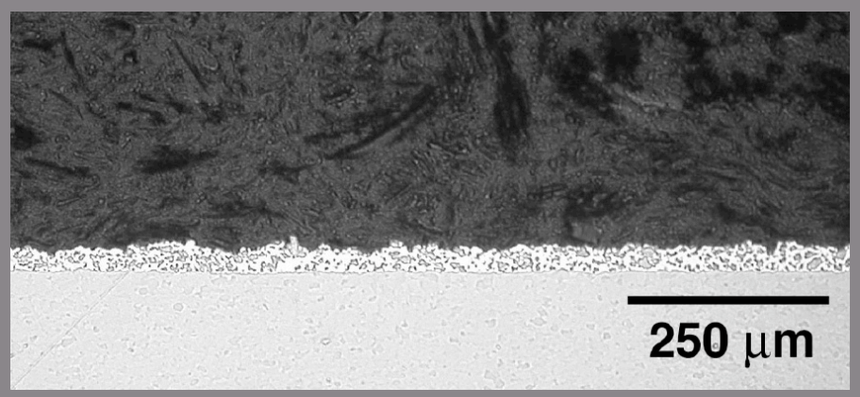
Al-Trans® Kinetic Metallization

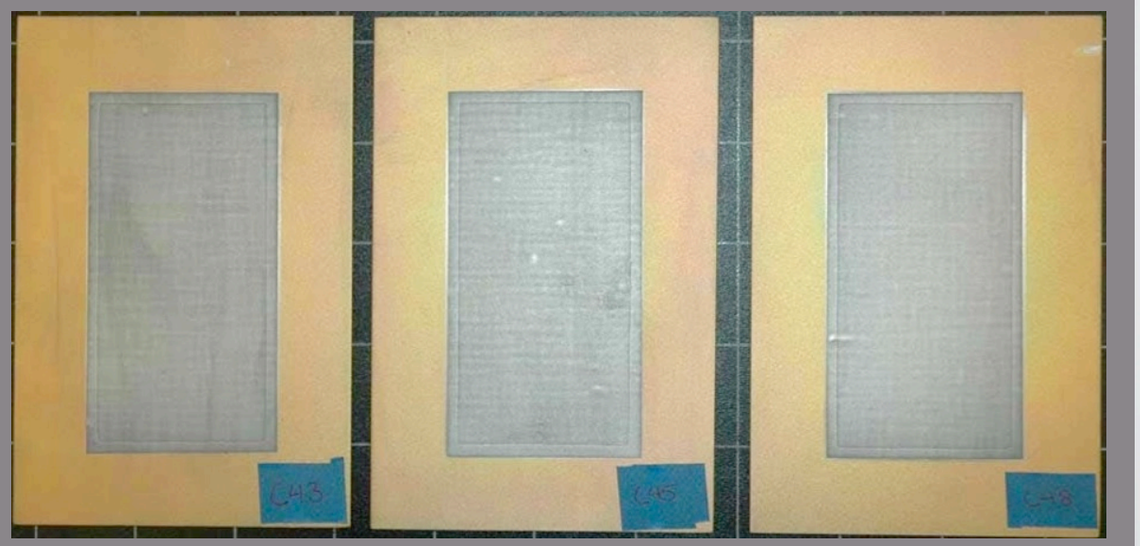
- Portable KM System
  - Handheld KM spray gun
  - Cartridge powder canisters
- Al-Trans® Coating
  - Aluminum-Transition Metal (Cr)
  - Superior corrosion resistant
  - Replaces IVD-Al and Cd
  - Replaces liquid-based plating

Qualification of Portable System for Repair of Damage IVD-Al Coatings



Laboratory Model of Handheld KM Gun

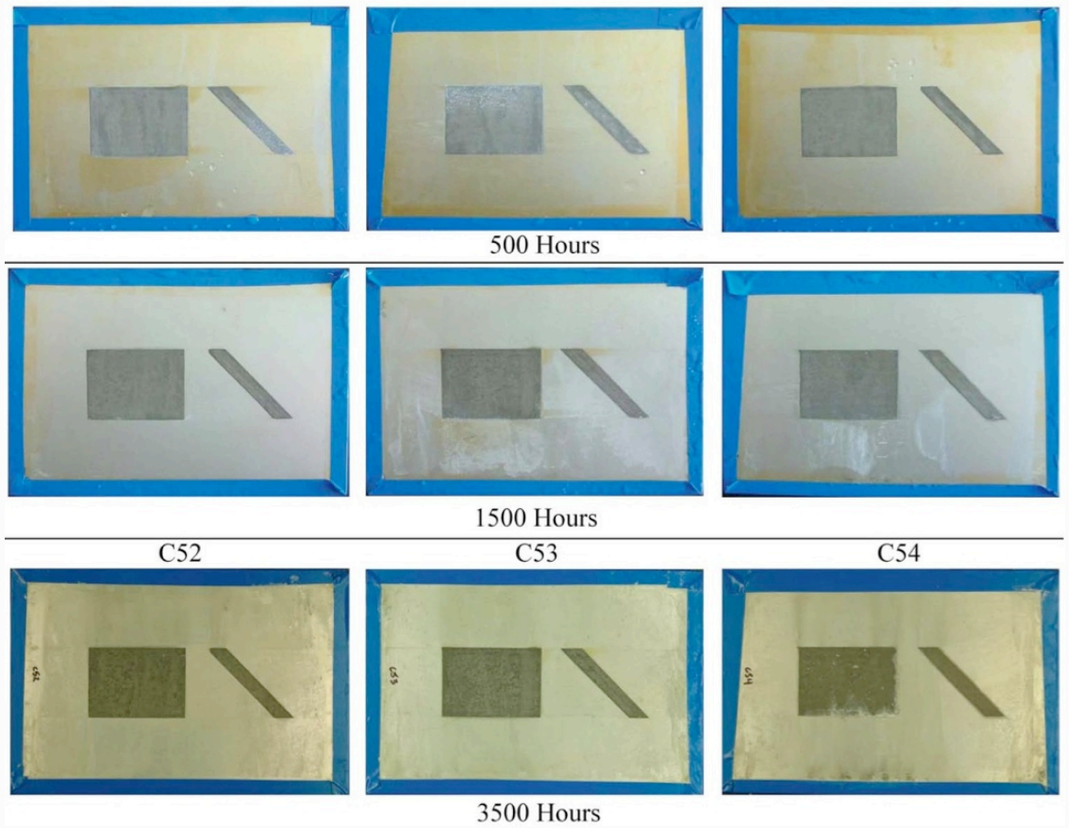




KM Al-Trans® Repair Coupons - 1.5±0.3 mils

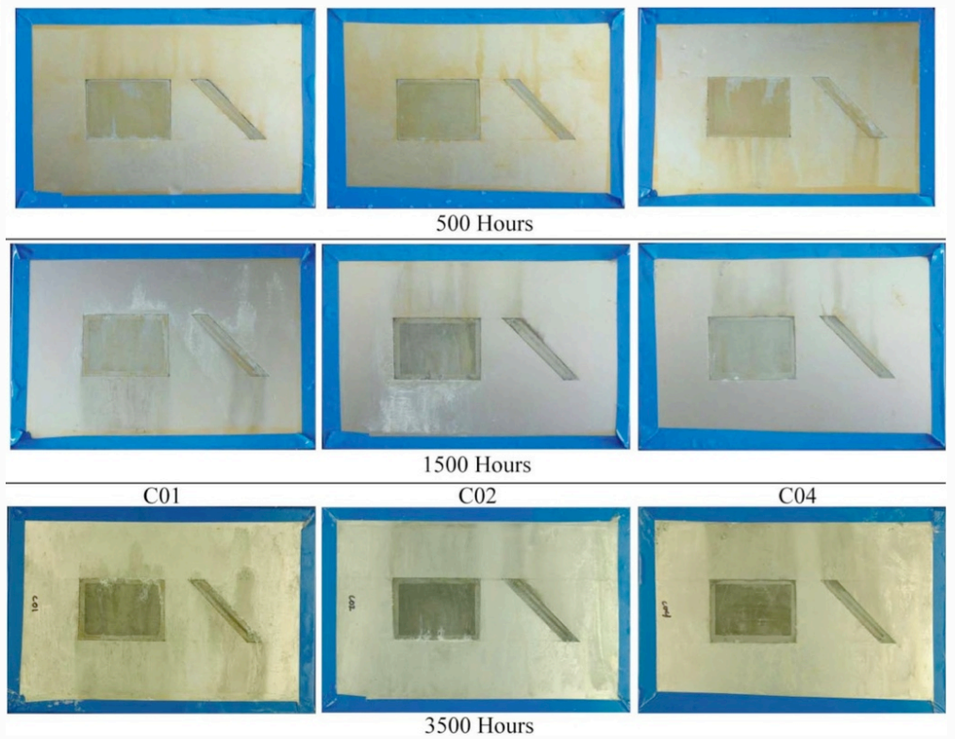
Al-Trans® Kinetic Metallization Qualified per JTP-2003

General & Galvanic Test	Reparability Test	Reparability Test
Strip-ability	Appearance	Unscribed Salt Fog
Open Circuit Potential	Bend Adhesion	Scribed Salt Fog
EIS/Tafel Analysis	Paint Adhesion	Unscribed SO_2 Salt Fog
Visual Exam	Scribed Painted Coating	Scribed SO_2 Salt Fog

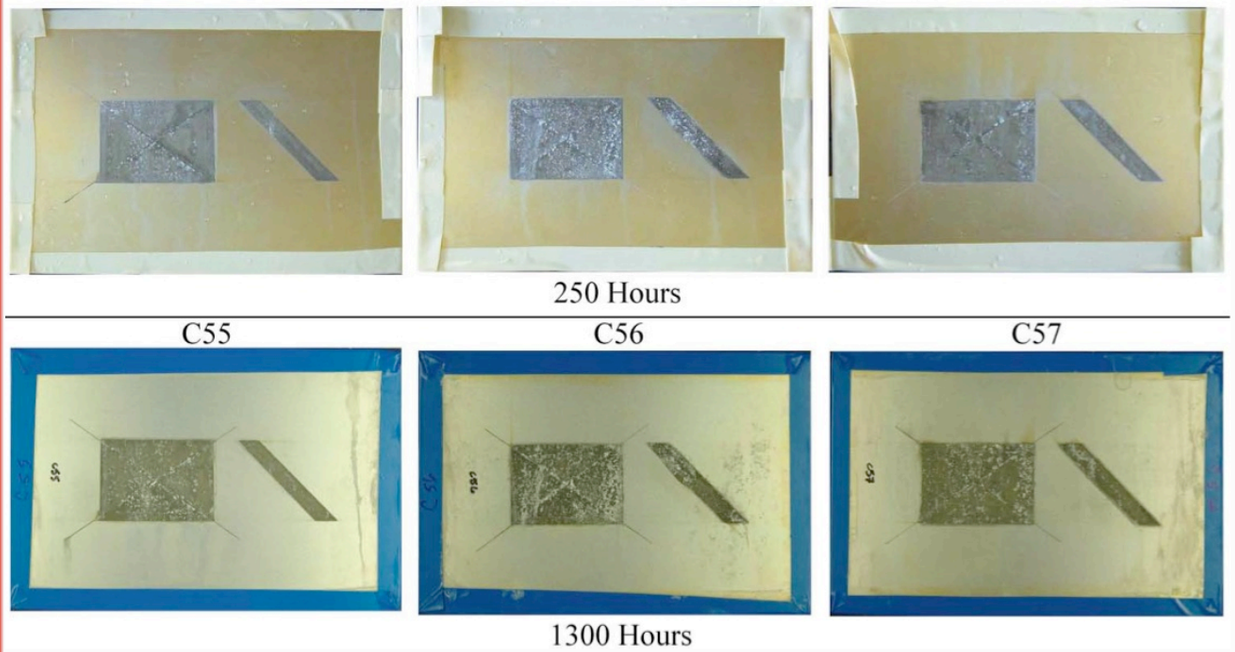


3500 Hrs Neutral Salt Fog
KM Al-Trans®

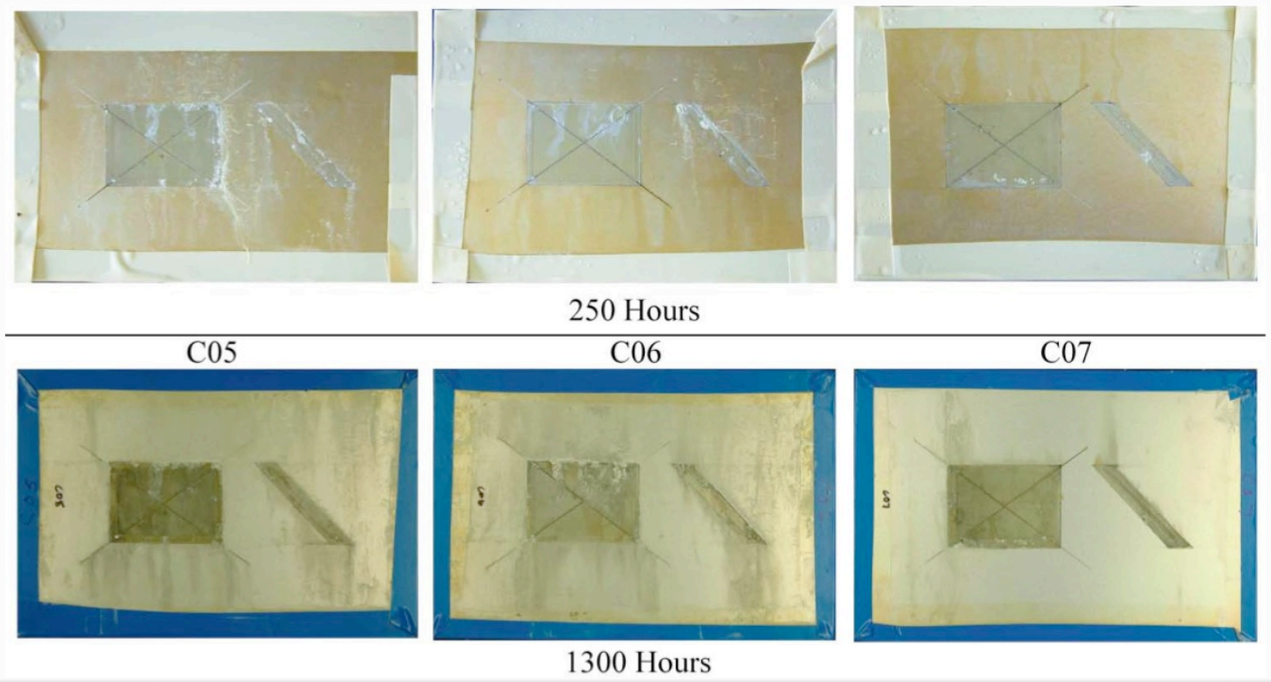
3500 Hrs Neutral Salt Fog
Brush Cd - Cr6+
Control Specimens



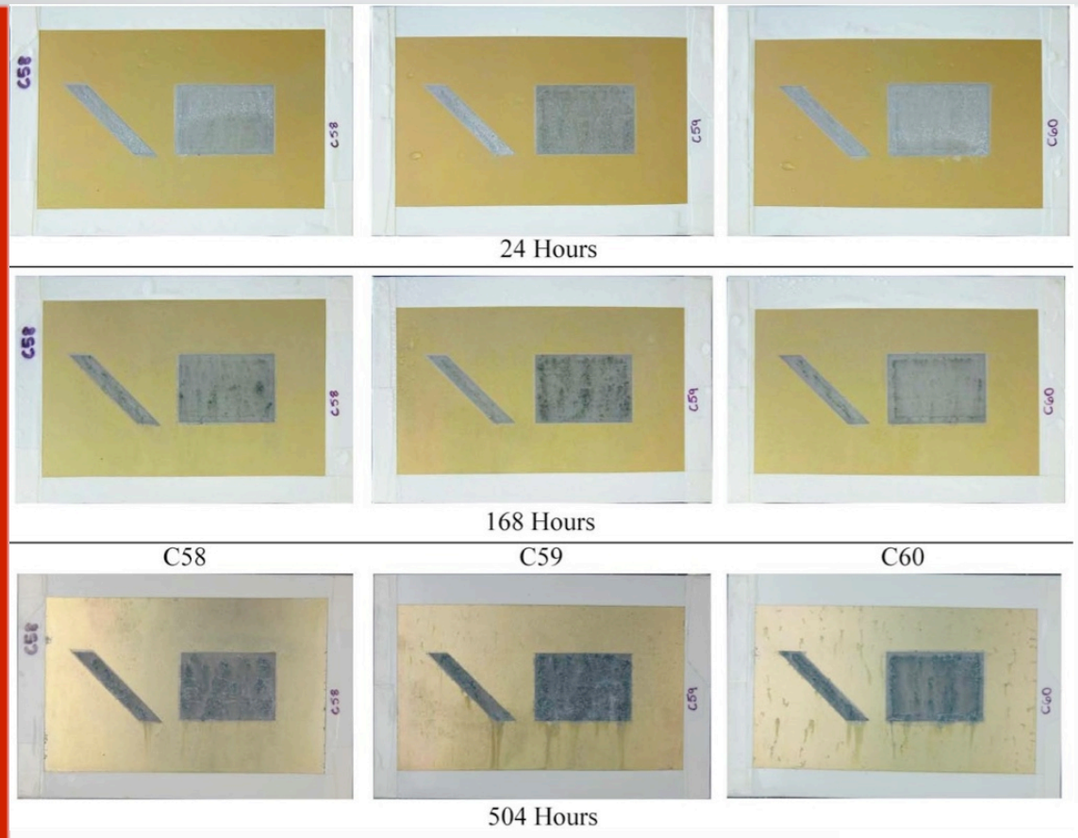
1300 Hrs Neutral Salt Fog
Scribed KM Al-Trans®



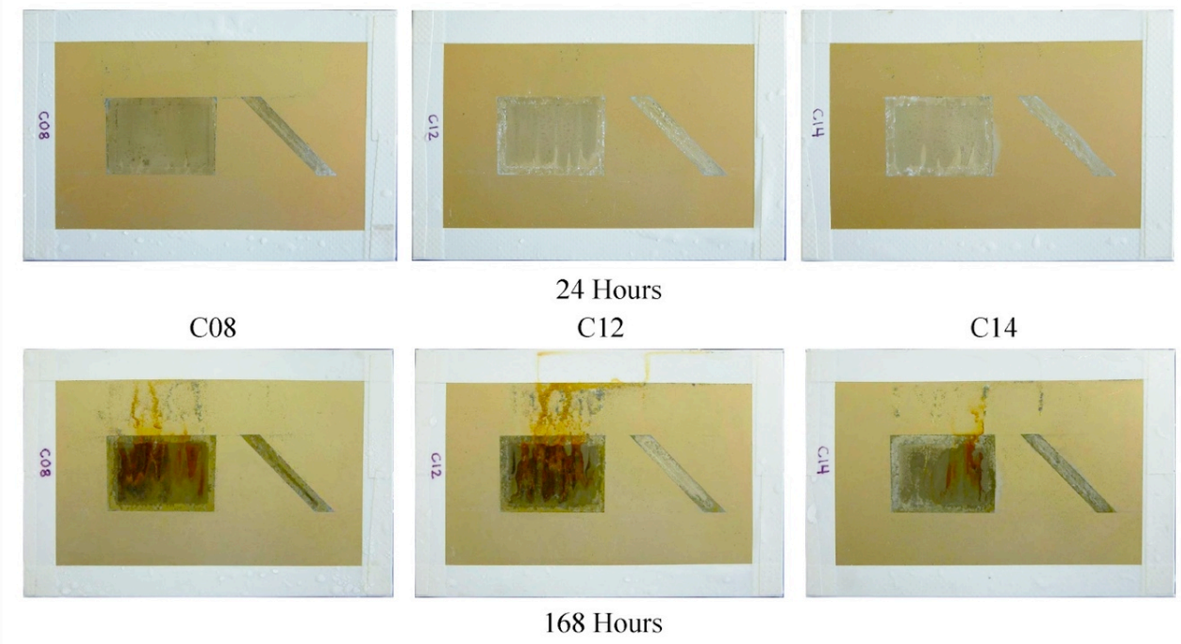
1300 Hrs Neutral Salt Fog
Scribed Brush Cd - Cr6+
Control Specimens



500 Hr Cyclic SO_2 Salt Fog
KM Al-Trans®



168 Hrs Cyclic SO_2 Salt Fog
Brush Cd - Cr6+
Control Specimens



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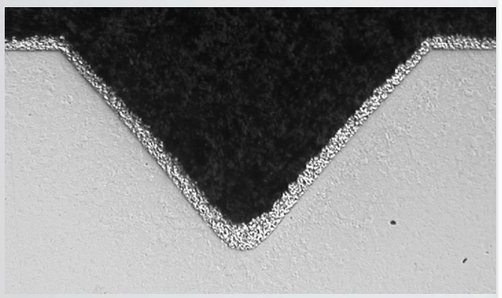
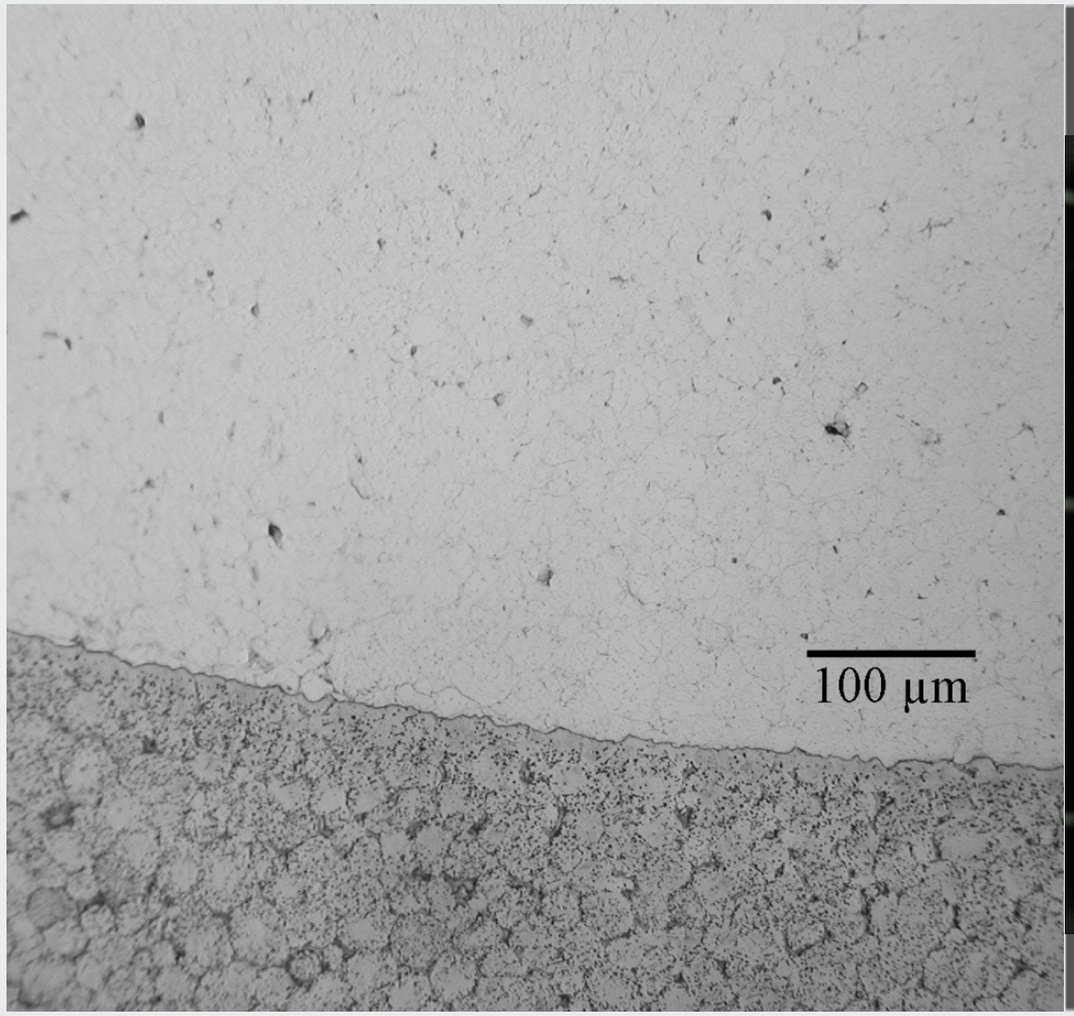
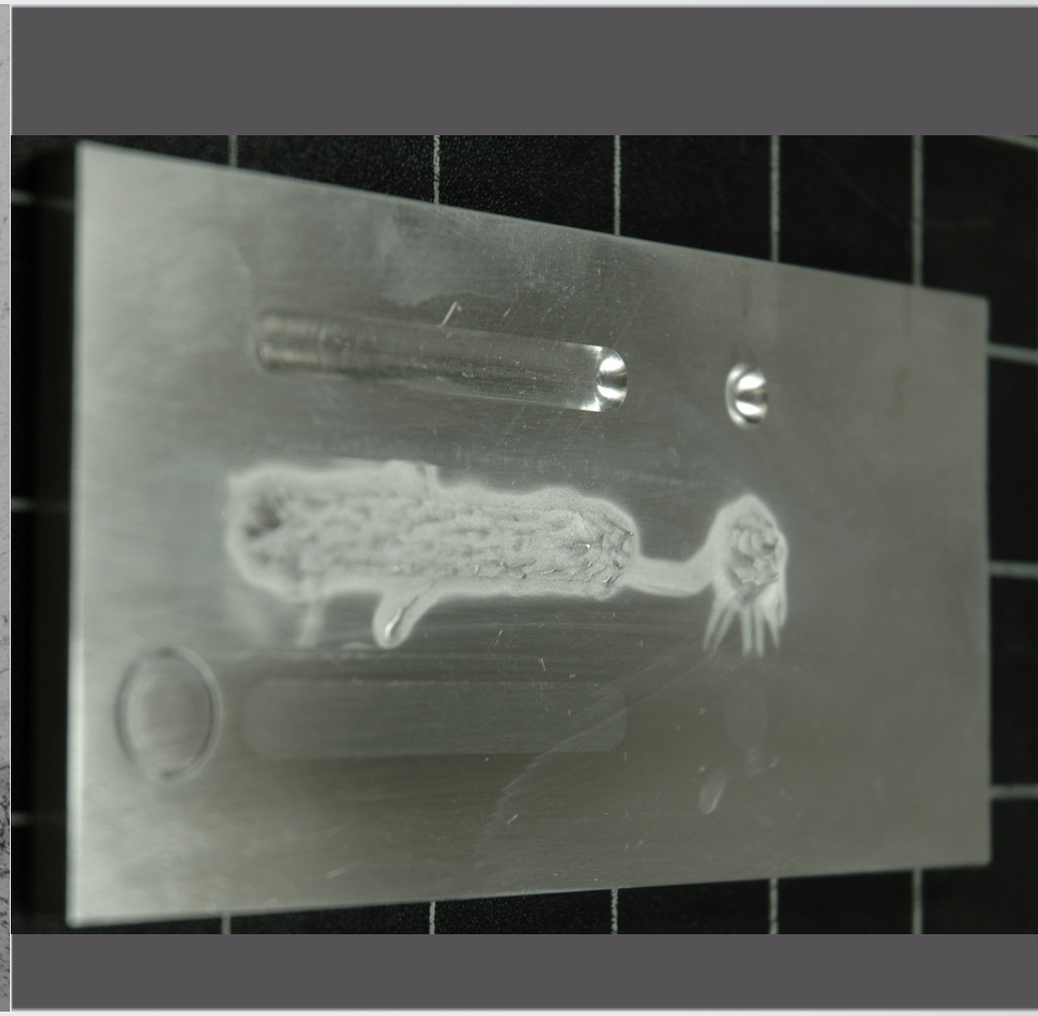
JTP-2003
Al-Trans® Kinetic Metallization



Reparability Test	JTP	Acceptance Criteria	Pass/Fail
Hydrogen Embrittlement	3.6.1 3.7.1	200 Hr/75% ASTM F519	Pass
Hydrogen Re-Embrittlement	3.6.1 3.7.1	200 Hr/75% ASTM F519	Pass
Corrosion Resistance 14 Fluids	3.3.4	No Coat Degradation Compared to Brush Cd	Pass
Stress Corrosion Cracking	4.3	SEM Fractography	Pass

Al-Trans® Kinetic Metallization Repair Demo IVD-Al on F-18 Axle





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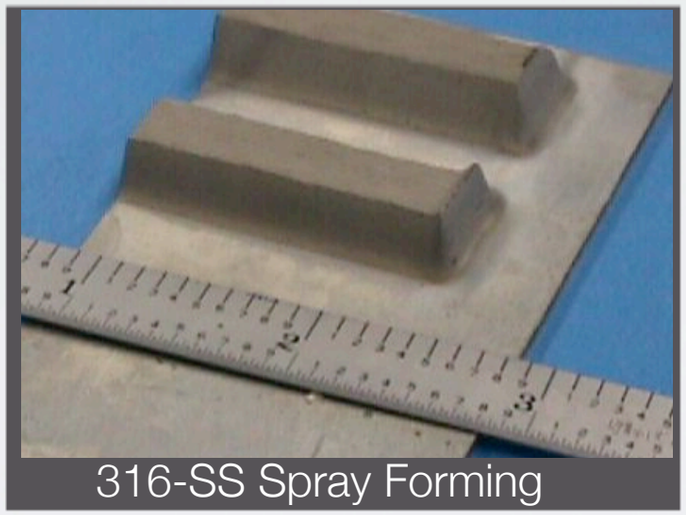
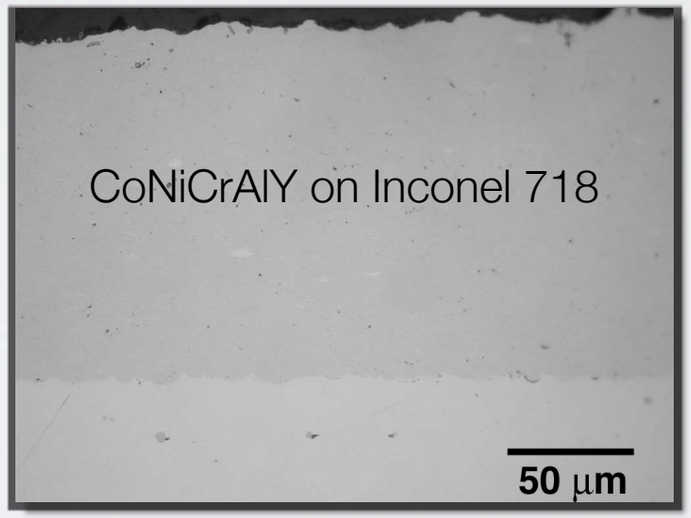
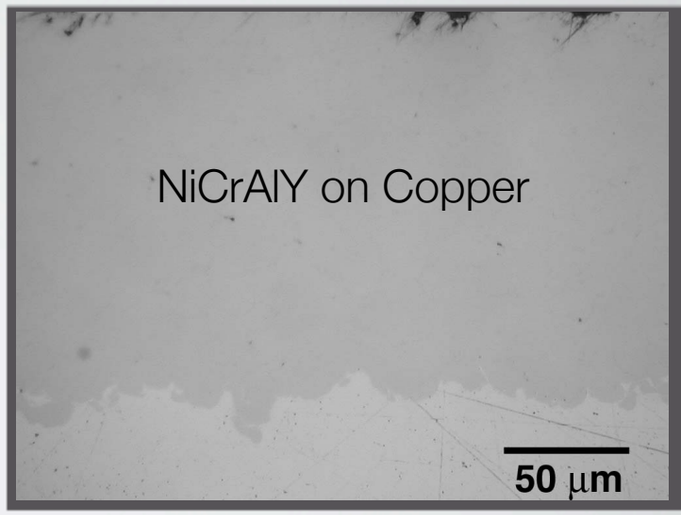
KM Fillet Repair CP-Al on ZE41A Mg Alloys



316-SS Spray Forming





Other Coating Applications Using Kinetic Metallization Systems

Inovati

Ralph Tapphorn, VP of Tech.

Phone (805) 571-8384 X12

Mobile (805) 637-7040

rtapphorn@inovati.com